Visual Motion Integration and Segmentation

Lee Stone, Brent Beutter, Jean Lorenceau, Guillaume Masson, Daniel Mestre

Much has been learned about the human ability to detect and discriminate information within local patches of image motion, and a model consisting of motion-energy detectors is a good descriptor of human low-level motion detection. This simple quasilinear view, however, does not adequately describe human performance in motion tasks that require either global integration across the image or segmentation of multiple overlapping independent motions presented simultaneously, yet these two abilities are essential components of many aerospace tasks. The overall goal of this project is to understand human performance in visual motion integration and segmentation tasks. The specific aim is to examine the abilities and limitations of humans to perform the global integration used to estimate object direction, and to use motion cues to segment images into discrete objects.

Current models of human motion processing use a first stage of local motion-energy sensors and a second-stage integration rule that combines local edge-motion signals to derive a global object-direction signal. Research has shown that simple vector averaging of the local motion signals cannot account for human direction judgments. Furthermore, by showing that the static spatial configuration influences motion integration, it has been demonstrated that no algorithm that merely combines local motion information can account for human performance.

Another difficult problem facing the human visual system is deciding when to combine local motion signals (that is, to assume they come from the same object) and when to segregate them (that is, to assume they come from different objects) as a first step in using motion to determine depth relationships. A clear understanding of this ability and its limitations is critical for the design of head-up, augmented-reality, or any other display that uses superimposed imagery. The limitations in human visual segmentation performance related to three factors were measured: mean speed, eccentricity, and spatial scale. The major findings are summarized in the figure. They are: (1) that segmentation from speed cues breaks down at mean speeds above approximately 8 degrees per second; and, (2) that the spatial resolution of the segmentation process is quite fine even in the visual periphery. Both of these findings are consistent with the view that the primary visual cortex (V1) plays a critical role.

Point of Contact: L. Stone
(650) 604-3240
lstone@mail.arc.nasa.gov

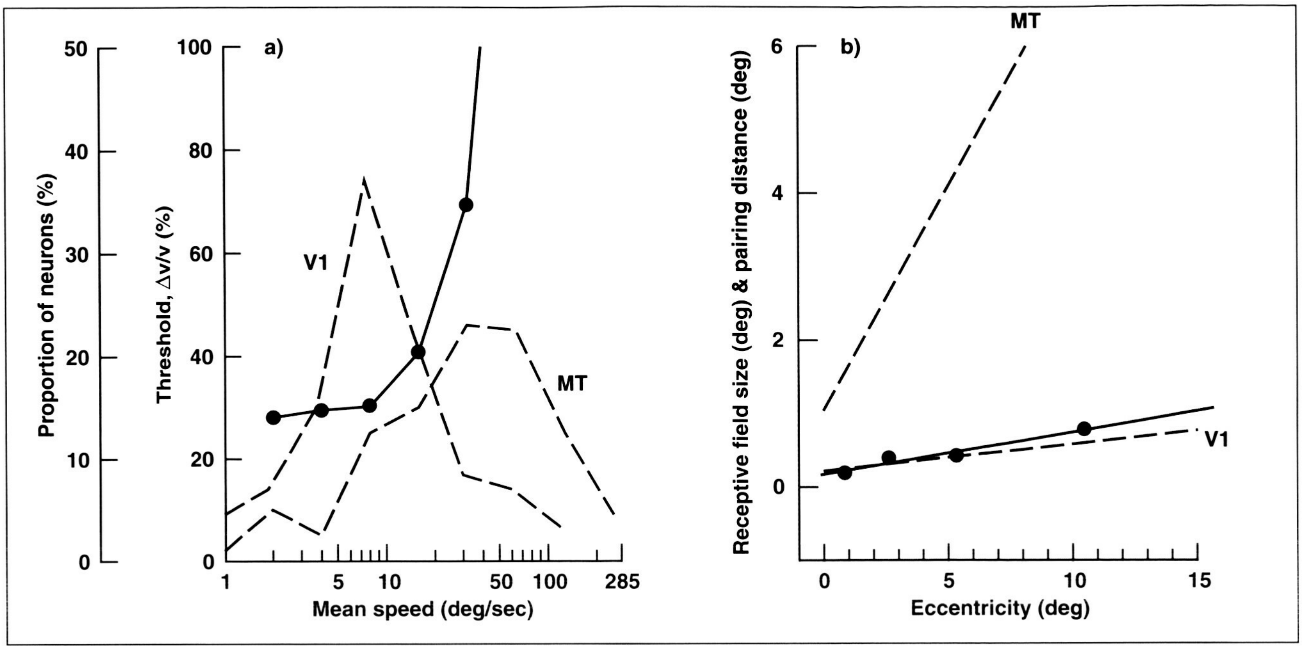

Fig. 1. Human speed-based segmentation performance. a. Human speed-segmentation thresholds are plotted as a function of mean display speed (solid circles and trace). Note the sharp decrement in performance for speeds above approximately 8 degrees per second, consistent with the range of speed tunings found in the primary visual cortex (V1) and inconsistent with the higher speed range of extrastriate visual cortical areas beyond V1, such as the middle temporal area (MT). The distributions of preferred speeds for neurons in areas V1 and MT (from earlier studies by others) are shown for comparison as dashed traces. b. The minimum spatial scale for segmentation (pairing distance) is plotted as a function of eccentricity in the visual field (solid circles and trace). Note that the smallest effective spatial scale for segmentation remains small (approximately 1 degree) even out to approximately 15 degrees of eccentricity. Again, such performance is consistent with a mechanism with a receptive field size similar to that of V1 neurons and much smaller than those of MT neurons (plotted for comparison as dashed traces from earlier studies by others).

Computational Models of Human Eye-Movement Behavior

Lee Stone, Brent Beutter, Miguel Eckstein, Jean Lorenceau

Humans interact with visual displays not by passively absorbing the information like a fixed camera, but by actively searching for areas with relevant information, and by following the motion of features of interest. The specific aim of this project is to develop and test computational models of human eye-movement control with particular emphasis on two types of eye-movement behaviors: search saccades and smooth pursuit. The overall goal is to incorporate the knowledge of eye-movement behavior acquired in our laboratory into computational models that can serve as design tools in the development of safer, more effective visual displays, interfaces, and training methods, matched to human abilities and limitations.

Most current models of human vision have focused on the passive ability to detect, discriminate, or identify targets in noise in carefully controlled laboratory conditions in which eye movements are suppressed. However, when humans interact with a